BREEDING ECOLOGY OF COMMON MYNA *ACRIDOTHERES TRISTIS* WITH SPECIAL REFERENCE TO THE EFFECT OF SEASON AND HABITAT ON REPRODUCTIVE VARIABLES[1]

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(*With three text-figures*)

Key words: Breeding ecology, *Acridotheres tristis,* breeding season, habitat effect, reproductive success

Breeding ecology of common myna *Acridotheres tristis* was studied in nest boxes and natural nests at Ludhiana, India. Breeding season extended from March to September. Nesting material included twigs, leaves, feathers, paper and plastics; the first two material types being used in significantly greater amounts. Size and fresh weight of eggs differed significantly among females, although successive eggs within a clutch did not differ significantly. Brood number, egg sequence and laying season did not affect egg size, whereas habitat around nests affected both the breadth and volume of eggs. Average clutch size was 4.29 ± 0.85 (sd). Clutch size did not vary with brood number and habitat but laying season affected it significantly. Clutches laid early in the season were bigger and there was a steady decline in average clutch size with the advancement of laying season. Brood number, laying season and habitat did not affect the number of eggs hatched or young fledged per clutch. Incubation period ranged between 11 and 14 days and averaged 12.73 ± 0.88 days. Hatching and nesting success were recorded as 66.1% and 34.4%, respectively. Average nestling period was 21.75 ± 2.78 days. Growth of nestlings showed sigmoid curve. Hatching failure and predation were the most important factors of egg mortality, whereas predation, intraspecific rivalry and starvation accounted for most of the nestling mortality. Significantly greater proportion of hole nests (80%) were successful (produced atleast one fledgling) compared with open nests (35.7%). Overall, an average production of 1.4 fledglings per nesting pair was recorded. This study suggests that laying season and habitat of the common myna significantly affect its clutch size and egg size respectively.

INTRODUCTION

The common myna *Acridotheres tristis,* one of the very common Indian birds, is distributed ubiquitously throughout the Indian subcontinent (Ali and Ripley, 1987). Reports on some breeding parameters of this species are available in literature from as early as 1889 when it was restricted to a few parts of the world (Long, 1981). Later on, it spread to neighbouring areas like Vietnam, Malaysia and Singapore as a result of extension of range. But it was deliberately introduced into Australia, New Zealand, Mauritius and certain other islands like Hawaii, Fiji and Malagasy to control insects (Long, 1981). Most of the introductions were successful probably because of its diverse feeding habits and its ability to accept any suitable site for nesting.

Despite the wide distribution and ecological importance of common myna, very meagre information is available on its breeding ecology (Lamba, 1963; Sengupta, 1968). The present study was conducted to obtain quantitative data on breeding of this species in an intensively cultivated habitat and to examine the effect of laying season and habitat on reproductive performance. A comparative account of

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reproductive performance of common myna in nest boxes and natural sites has been published elsewhere (Dhanda and Dhindsa, 1996).

Material and Methods

The study was conducted during 1992 in the campus of the Punjab Agricultural University, Ludhiana (30° 56' N, 75° 52' E, 247 m above msl), Punjab, India. The study area (*ca* 640 ha) includes large tracts of agricultural fields, fruit orchards and woodlots, in addition to university buildings and residences interspersed with roads and lawns. Trees are located around orchards, canal sides, poultry farms, fish farms and all along the campus roads.

Twenty-six nests of the common myna in natural sites were selected at random and marked for regular observations on various parameters of breeding ecology. Thirty nest boxes (15 wooden and 15 made of polyvinyl chloride (PVC), were put up in different parts of the study area during the last week of February. Each rectangular wooden nest box measured 22 x 22 cm at the base, 34 cm at the rear and 23 cm in front. A PVC pipe of 16 cm diameter was used for preparing circular nest boxes, each 33 cm high at the rear and 28 cm high in front, with a wooden base and a slanting lid. All boxes had an entrance hole (6 cm in diameter) on the front, 2.5 cm from the top. One box was placed in a building ventilator, whereas the remaining 29 boxes were fixed to trees at an average height of 3.95 ± 0.56 (sd) and facing different directions.

All nests were monitored daily during the egg laying period, twice a week after clutch completion and again daily near the expected date of hatching. Eggs were measured and weighed within 24 hrs of laying. Egg volume was calculated as 0.51 x length x $(\text{breadth})^2$ following Hoyt (1979). All young were weighed with a Pesola balance on alternate days till they were 17 days old, after which weighing had to be stopped as the nestlings tried to jump from the nest on approach. In nests where completed clutches or already hatched young were found, laying dates were calculated assuming that females laid one egg a day(d). Incubation started after laying of the last egg and lasted 13 d, and nestlings stayed in the nest for 22 d (Sandhu, 1993). The fledging date was recorded by daily observation of nests. After fledging, the nest contents (if dry) were sorted and weighed. Wet and clumped nest contents were discarded. Twelve boxes were put up again to study the second clutches.

Eggs which did not hatch till the young were a week old, were removed from the nests/ boxes and were later examined to ascertain the cause of unhatchability. Young dying within the nests were examined at the Virology and Parasitology Laboratory of the Punjab Agricultural University. Data were analysed using standard parametric and non-parametric statistical methods (Zar, 1984). To examine the effect of laying season, brood number, egg sequence and habitat on reproductive variables, data from nest boxes alone were used. All other breeding parameters were quantified by pooling data from boxes and natural nests.

Results

Breeding season

The breeding activity of the common myna commenced in March and continued till September. Mynas started adding nesting material to nest sites in the first week of March and 15 nest boxes were occupied by 16th March. The first egg was laid on 31st March and the first batch of 4 young hatched on 17th April. The first peak in breeding activity was observed from 15th April to 15th May and the second around 1st July (Fig. 1). Some birds, however, started breeding late, probably because of non-availability of suitable nesting sites. Active nests of this species on electric and telephone poles were found only after June. The first batch of nestlings fledged on 11th May. The last batch of nestlings was observed being fed by parent birds in a natural-hole nest

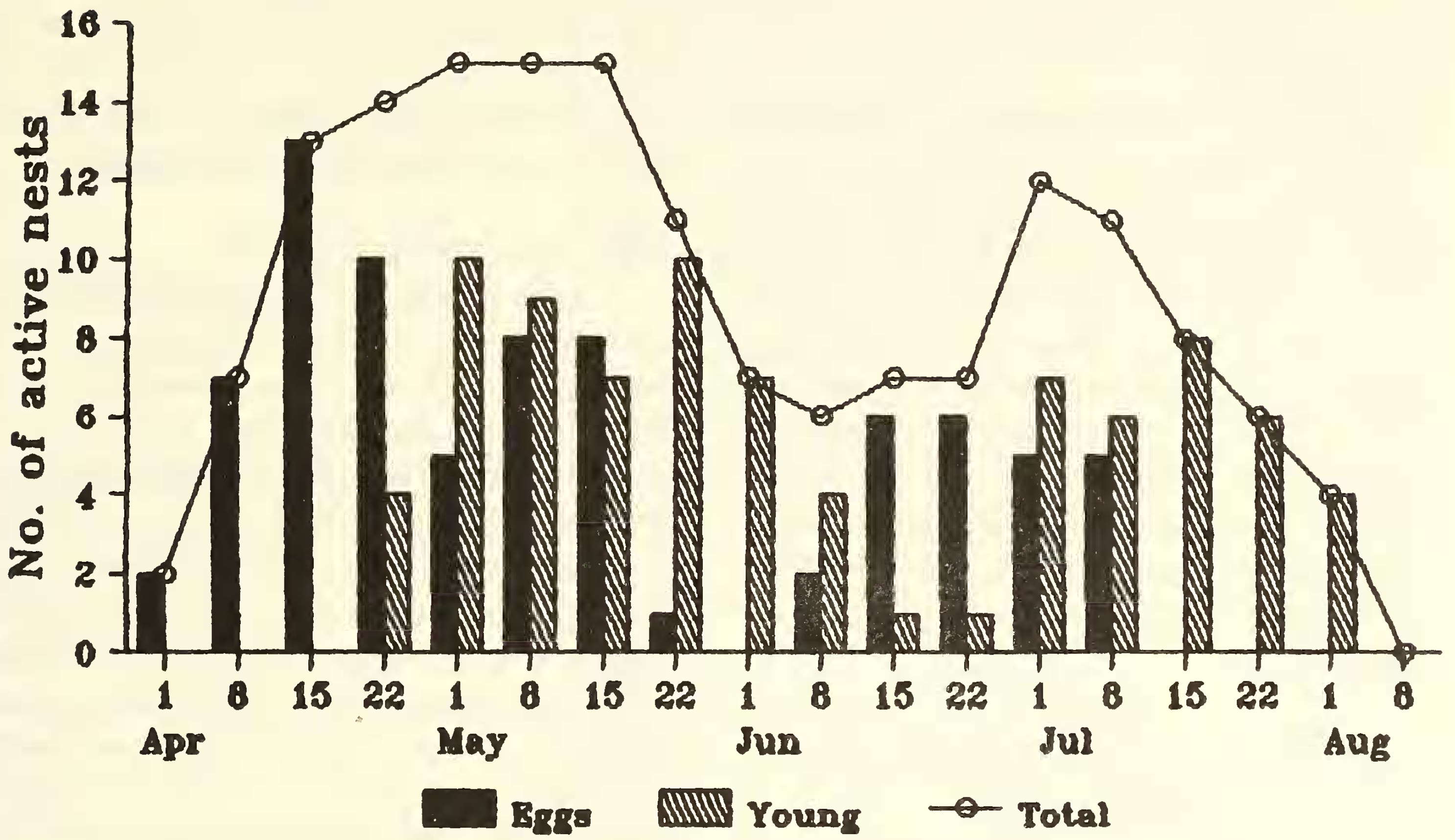

Fig. 1. Pattern of breeding activity of Common Myna *Acridotheres tristis* during 1992

on 27th September, which probably fledged in the beginning of October. Thus, the breeding season in the common myna was considerably long, extending over a period of six months from March to September.

Nesting Material

Nesting birds did not bring nesting material from far off distances. All leaves and twigs found in the nests belonged to the nest tree itself or the adjacent trees. The usual nesting material consisted of twigs and leaves of plants. Twigs and leaves of neem *Azadirachta indica* and dhrek *Melia azedarach* trees, if available nearby, were the most frequently used. Other materials like feathers, paper, plastic bags, sweet wrappers etc., were also found frequently in all nests. Occasionally, materials like snake exuviae, tail of squirrel, bird bones and fish scales were also included.

In 15 nests, whose nesting material was sorted and weighed, twigs and leaves were used in significantly greater quantities than feathers, paper and plastics (One way ANOVA: F=11.84, df = 3,56, P < 0.0001, Table 1)

Table 1
NESTING MATERIAL IN COMMON MYNA NESTS IN NEST BOXES AND NATURAL NESTS

Nesting Material	Amount (g) (n = 15)
Paper & plastics	$5.33^a \pm 1.29$
Feathers	$11.58^a \pm 3.55$
Twigs	$49.07^b \pm 8.52$
Leaves	$47.63^b \pm 9.73$
Difference between material types (ANOVA)	F = 11.84 df = 3 & 56 P = 0.0001

Figures with same superscripts in a column do not differ significantly (Tukey's multiple range test)

Eggs

Eggs were laid at 24 hr intervals except for three instances where one of the successive eggs was laid at a 48 hr interval. These were oval, longer than broad and turquoise-blue in colour.

The colour turned slightly dull near hatching. Weight of freshly laid eggs ranged from 6.0 to 8.5 g and averaged 7.36 ± 0.10 g (mean ± se, n = 35, Table 2). The last egg appeared comparatively lighter in weight as compared to the first, especially in clutches bigger than 4 eggs. However, differences in the average weight of successive eggs were non-significant (F=0.937, df = 4, 30, P = 0.456; Table 2). The average egg weight in individual clutches ranged from 6.50 ± 0.36 g to 8.23 ± 0.14 g and differed significantly among different females (F = 7.65, df = 8, 26, P < 0.001; Table 2). The length, breadth and volume of 152 eggs of common myna averaged 29.11 ± 1.37 mm, 21.41 ± 0.71 mm and 6.82 ± 0.63 cm^3, respectively.

TABLE 2
WEIGHT OF EGGS OF COMMON MYNA

Box No.	Weight of eggs (g) 1st egg	2nd egg	3rd egg	4th egg	5th egg	Mean ± se
1	7.5	7.0	7.0	broke	6.8	7.08 ± 0.15
2	7.8	8.0	7.8	8.0	—	7.09 ± 0.06
3	7.6	6.2	6.0	6.2	—	6.05 ± 0.36
12	8.0	8.0	8.0	7.0	—	7.75 ± 0.25
13	7.5	7.3	7.0	7.0	6.8	7.12 ± 0.13
22	7.6	7.2	8.2	7.5	—	7.63 ± 0.21
23	7.1	7.0	7.0	6.9	6.9	6.98 ± 0.04
24	—	8.2	8.5	8.0	—	8.23 ± 0.14
27	7.5	7.5	—	—	—	7.05 ± 0.00
Mean ± se	7.58 ± 0.09	7.38 ± 0.21	7.44 ± 0.29	7.23 ± 0.25	6.83 ± 0.03	7.36 ± 0.10 (n=35)

Difference among successive eggs: F = 0.937, df = 4, 30, P = 0.456

Difference among nest boxes: F = 7.65, df = 8, 26, P < 0.001.

Egg size in relation to brood number, laying sequence and laying month

When egg size of the first, second and third broods was compared using one way ANOVA, difference among broods were non-significant for all the three size parameters (Table 3). Similarly, successive eggs of the clutches did not differ significantly in size (Table 4). No differences could be detected in size of eggs laid in April, May and June (Table 5). These analyses suggested that brood number, laying sequence and laying month did not affect egg size.

Effect of habitat on egg size

Data on egg size were available from nest boxes put up in six different habitats, *viz.*, fish farm, poultry farm, shisham woodlot, forestry area, orchards and cultivated fields. One way ANOVA showed no effect of habitat on the length of the eggs, although habitat significantly affected both breadth and volume of eggs (Table 6). Eggs in the poultry farm area were broadest and with biggest volume, followed by those in cultivated fields and orchard. Egg breadth was smallest in shisham woodlot, whereas volume was smallest in shisham woodlot, and at par in forestry area and fish farm. The probable reason for the biggest egg size in poultry farm may be greater abundance of food (scattered poultry feed) available to the laying females in that area.

Clutch size

The clutch size of the common myna varied from 3 to 7 but clutches of 4 and 5 eggs were the most frequent (Fig. 2). Of 52 clutches laid in nest boxes and natural nests, 8 were of 3 eggs, 25 of 4 eggs, 16 of 5 eggs and two of 6 eggs each. Only one clutch in a nest box contained 7 eggs. Clutch size averaged 4.29 ± 0.85 (sd).

Clutch size in relation to brood number, laying season and habitat

Clutch size did not differ significantly among first, second and third broods (Table 7). Some birds started breeding early (beginning of April), whereas the others started late (in June or July). The clutch size in June (3.56 ± 0.13 se, n = 16) did not differ significantly from that in July (3.67 ± 0.33, n = 3, t = 0.33, P > 0.50). So the data of these two months were pooled and taken as of late breeding season. The effect of laying season on clutch size was highly significant,

TABLE 3

EGG SIZE IN RELATION TO BROOD NUMBER IN COMMON MYNA

	Brood number			Difference among broods (df = 2 & 130)
	1 (n = 97)	2 (n = 24)	3 (n = 12)	
Length (mm)	28.87 ± 0.14	29.53 ± 0.34	29.17 ± 0.29	*F* = 2.28 (ns)
Breadth (mm)	21.44 ± 0.07	21.35 ± 0.19	21.31 ± 0.08	*F* = 0.28 (ns)
Volume (cm^3)	6.78 ± 0.06	6.89 ± 0.17	6.76 ± 0.08	*F* = 0.31 (ns)

± figures represent standard error; ns = non-significant

TABLE 4

EGG SIZE IN RELATION TO EGG SEQUENCE IN COMMON MYNA

Egg sequence in clutch	Sample size	Length (mm)	Breadth (mm)	Volume (cm3)
First egg	14	29.09 ± 0.30	21.49 ± 0.18	6.86 ± 0.15
Second egg	14	28.81 ± 0.38	21.30 ± 0.18	6.68 ± 0.17
Third egg	14	29.23 ± 0.44	21.41 ± 0.20	6.86 ± 0.21
Fourth egg	15	28.65 ± 0.35	21.33 ± 0.17	6.66 ± 0.15
Fifth egg	9	28.66 ± 0.43	21.0 0 ± 0.16	6.44 ± 0.15
Sixth egg	3	28.77 ± 1.87	21.20 ± 0.74	6.65 ± 0.84
Difference:				
F-value		0.339	0.604	0.601
(df = 5,63)		ns	ns	ns

± figures represent standard error; ns = non-significant

TABLE 5

SIZE OF COMMON MYNA EGGS IN RELATION TO LAYING SEASON

	Early (April) (n = 78)	Mid (May) (n = 36)	Late (June) (n = 19)	Difference (df = 2, 130)	
				F	*P*
Length (mm)	28.96 ± 1.4	29.07 ± 1.5	29.10 ± 1.15	0.119,	ns
Breadth (mm)	21.39 ± 0.68	21.59 ± 0.68	21,19 ± 0.82	2.135,	ns
Volume (cm^3)	6.77 ± 0.61	6.93 ± 0.71	6.67 ± 0.57	1.200,	ns

± figures represent standard deviation; ns = non-significant

TABLE 6

EFFECT OF HABITAT ON EGG SIZE OF COMMON MYNA

Habitat	No. of eggs	Length (mm)	Breadth (mm)	Volume (cm^3)
Fish farm	64	28.94	21.36^{ab}	6.75^{a}
Poultry farm	8	29.44	22.28^{c}	7.45^{c}
Shisham woodlot	19	28.84	21.17^{a}	6.61^{a}
Forestry area	23	29.73	21.32^{ab}	6.66^{a}
Orchard	15	29.66	21.54^{b}	7.01^{b}
Cultivated field	4	29.38	21.68^{bc}	7.04^{bc}
Difference among habitat (df = 5 & 127)		*F* = 1.075 ns	*F* = 3.47 $P < 0.006$	*F* = 2.96 $P < 0.02$

Figures with same superscripts in a column do not differ significantly (Tukey's multiple range test)
ns = non-significant

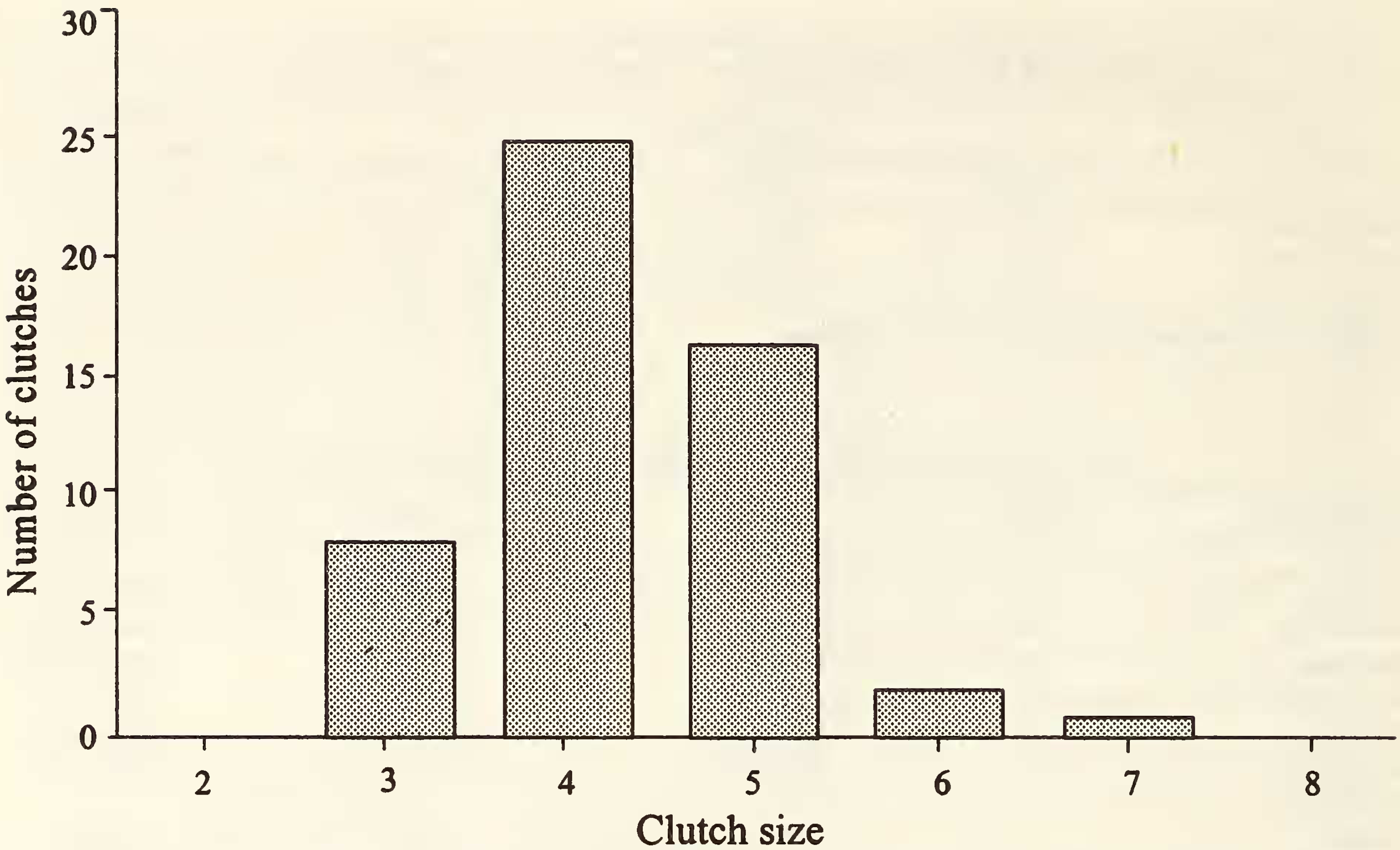

Fig. 2. Frequency of clutch size of Common Myna *Acridotheres tristis* during 1992

TABLE 7
EFFECT OF BROOD NUMBER ON CLUTCH SIZE, NUMBER OF EGGS HATCHED AND NUMBER OF YOUNG FLEDGED IN COMMON MYNA

Brood	Clutch size		No. hatched		No. fledged	
	Mean ± se	n	Mean ± se	n	Mean ± se	n
First	4.46 ± 0.15	37	2.90 ± 0.27	40	1.28 ± 0.18	47
Second	3.92 ± 0.15	12	2.67 ± 0.31	12	1.58 ± 0.28	12
Third	3.67 ± 0.33	3	2.67 ± 0.33	3	2.00 ± 1.00	3
Difference among broods	F = 2.916 (df = 2 & 49) ns		F = 0.122 (df = 2 & 52) ns		F = 0.717 (df = 2 & 59) ns	

showing a steady reduction in average clutch size with the advancement of season (Table 8). There was no significant effect of habitat on clutch size (Table 9).

Incubation period, hatching pattern and hatching success

Data on incubation period (time elapsed between the laying of the last egg of the clutch and hatching of the last young) were available for 15 clutches in nest boxes. The incubation period ranged from 11 to 14 days and averaged 12.73 ± 0.88 (sd) days.

Hatching in 21 clutches indicated an asynchronous pattern. The larger the number of young hatched, the longer was the hatching period. In larger clutches (4-5 eggs), hatching continued for 2-3 days. Two young hatched simultaneously on the first day of hatching in 8 cases, 3 young in 7 cases and 4 young in 2 cases.

TABLE 8
EFFECT OF LAYING SEASON ON CLUTCH SIZE, NUMBER OF EGGS HATCHED AND NUMBER OF YOUNG FLEDGED IN COMMON MYNA

Laying season	Clutch size		No. hatched		No. fledged	
	Mean ± se	n	Mean ± se	n	Mean ± se	n
Early (April)	$4.84^{c} \pm 0.19$	19	$3.37^{b} \pm 0.35$	19	1.58 ± 0.35	19
Mid (May)	$4.50^{b} \pm 0.15$	12	$3.50^{b} \pm 0.38$	12	1.43 ± 0.27	14
Late (June-July)	$3.58^{a} \pm 0.12$	19	$2.45^{a} \pm 0.26$	20	1.38 ± 0.23	21
Difference among seasons	$F = 18.562$ (df = 2 & 47) $P < 0.0001$		$F = 3.21$ (df = 2 & 48) $P < 0.05$		$F = 0.133$ (df = 2 & 51) ns	

Figures with same superscripts in a column do not differ significantly (Tukey's multiple range test) ns = non-significant

TABLE 9
EFFECT OF HABITAT ON CLUTCH SIZE, NUMBER OF EGGS HATCHED AND NUMBER OF YOUNG FLEDGED IN COMMON MYNA

Habitat*	Clutch size		No. hatched		No. fledged	
	Mean ± se	n	Mean ± se	n	Mean ± se	n
Fish farm	4.53 ± 0.29	15	2.60 ± 0.41	15	1.53 ± 0.40	15
Poultry farm	4.00 ± 0.00	2	2.33 ± 1.20	3	0.67 ± 0.67	3
Shisham woodlot	4.50 ± 0.22	6	3.67 ± 0.61	6	1.50 ± 0.50	6
Forestry area	4.22 ± 0.22	9	3.33 ± 0.24	9	2.00 ± 0.33	9
Orchard area	5.00 ± 0.00	3	3.33 ± 0.88	3	2.33 ± 0.33	3
Difference among habitats	$F = 0.624$ (df = 4,30) ns		$F = 0.933$ (df = 4,31) ns		$F = 0.846$ (df = 4,31) ns	

*Cultivated field area excluded from analysis since only clutch was recorded in this area
ns = non-significant

TABLE 10
HATCHING SUCCESS AND EGG MORTALITY IN COMMON MYNA (N = 54 NESTS)

	Number	% of total eggs
Total eggs laid	227	
Eggs hatched	150	66.1
Eggs lost	77	33.9
Hatching failure	42	18.5
Predation	22	9.7
Nest desertion	9	4.0
Handling loss	2	0.9
Intraspecific brood parasitism	2	0.9

In the rest of the four clutches, all young hatched at 1-day intervals.

Hatching success was recorded in 54 nests in all. Of 227 eggs laid in these nests, 150 hatched successfully, a hatching success of 66.1% (Table 10).

Egg mortality

Total egg mortality recorded in this study was 33.9%. Hatching failure was the most severe factor claiming 42 (18.5%) eggs (Table 10). Unhatched eggs were retained in nest boxes for such a long period that in five cases they were found intact even after fledging of young. In open natural nests, unhatched eggs were not found 2-4 days after hatching. Altogether, 13 unhatched eggs were examined after breaking the egg shell. Twelve of these eggs were found to be infertile, since no embryo formation was present. In one egg, however, a dead embryo was found in a late stage of development. The major cause of hatching failure, therefore, seemed to be infertility of eggs.

Predation (loss of all eggs and/or young from a nest) accounted for the loss of 22 eggs (9.7%) and was the second most important factor of egg mortality. Two nests were deserted for unknown reasons, leading to the loss of 9 eggs (3.96%). Two eggs (0.9%) were found cracked in a nest box in which intraspecific brood parasitism was recorded, while two eggs (0.9%), one each in two different clutches, were broken accidentally during egg measurements.

The young

The newly hatched pinkish young weighed 5-6 g and were covered with white, woolly, fluffy down feathers along the mid-dorsal line and on two lateral tracts. One patch of down feathers was present behind each eye, one on head and two small patches were visible on the lateral sides. Three rows of black heads of feather pins were visible through the translucent skin on the back and one row on each wing. The eyes were closed and the gape was pale yellow. The claws were soft and cream coloured.

Feather pins of different tracts pierced the skin in the following sequence: alar tract in 2-day old, femoral tract in 3-day old and humeral, caudal, spinal and cephalic tracts in 4-day old young. Eyes started opening 5 days after hatching. Feather pins of the posterior parts of the body were clearly visible and the wings looked quite dark because of very thick alar pins. On the 6th day, crural and capital feather tracts also appeared, alar pins were 2 mm long and eyes fully open in all the young.

One week old young of common myna clearly displayed all the feather tracts, although the pins were yet to open up. Two rows of wing quills had appeared on each wing, the posterior row being 5 mm in length. Remiges and rectrices had developed on the eighth day. The posterior row of remiges started opening at their terminal ends on the ninth day and the whole wing looked like a column of paint brushes placed side to side with their barbs touching the adjacent feathers. In 10-day old young, remiges were 2 cm and rectrices 1 cm long. Small brown feathers looked quite distinct on the dorsal side of the body. On the 11th day, all feathers except those of the capital tract started opening at their terminal ends, and the second row of rectrices also appeared. On the 12th day, all feathers on the body were partially open. The cephalic feather pins, however, opened on the 14th day.

With the full development of feathers, the two weeks old young were quite active. Distinct brown colour on the back was followed in appearance by black on the wings with a white patch on each wing. White colour at the tips of rectrices also became conspicuous with the growth of feathers.

Newly hatched nestlings gained weight rapidly during the first five days after hatching, followed by a steady decrease in growth rate. The young had attained maximum weight at the age of 15 days. Thereafter, the weight showed gradual decrease till fledging. Thus, the growth of young followed a sigmoidal curve (Fig. 3).

Feeding and care of young

Both parents were observed feeding the young. The food was brought at 2-5 min intervals. When both parents brought food simultaneously, only one of them entered the nest while the other waited outside. The parents were never observed removing faecal droppings from the nests, as a result of which a large amount of these were recovered from the nests. Unhatched eggs and some egg shells were also retained in the nests. Even the dead young were not removed. Both parents continued to feed the young for a few days after fledging.

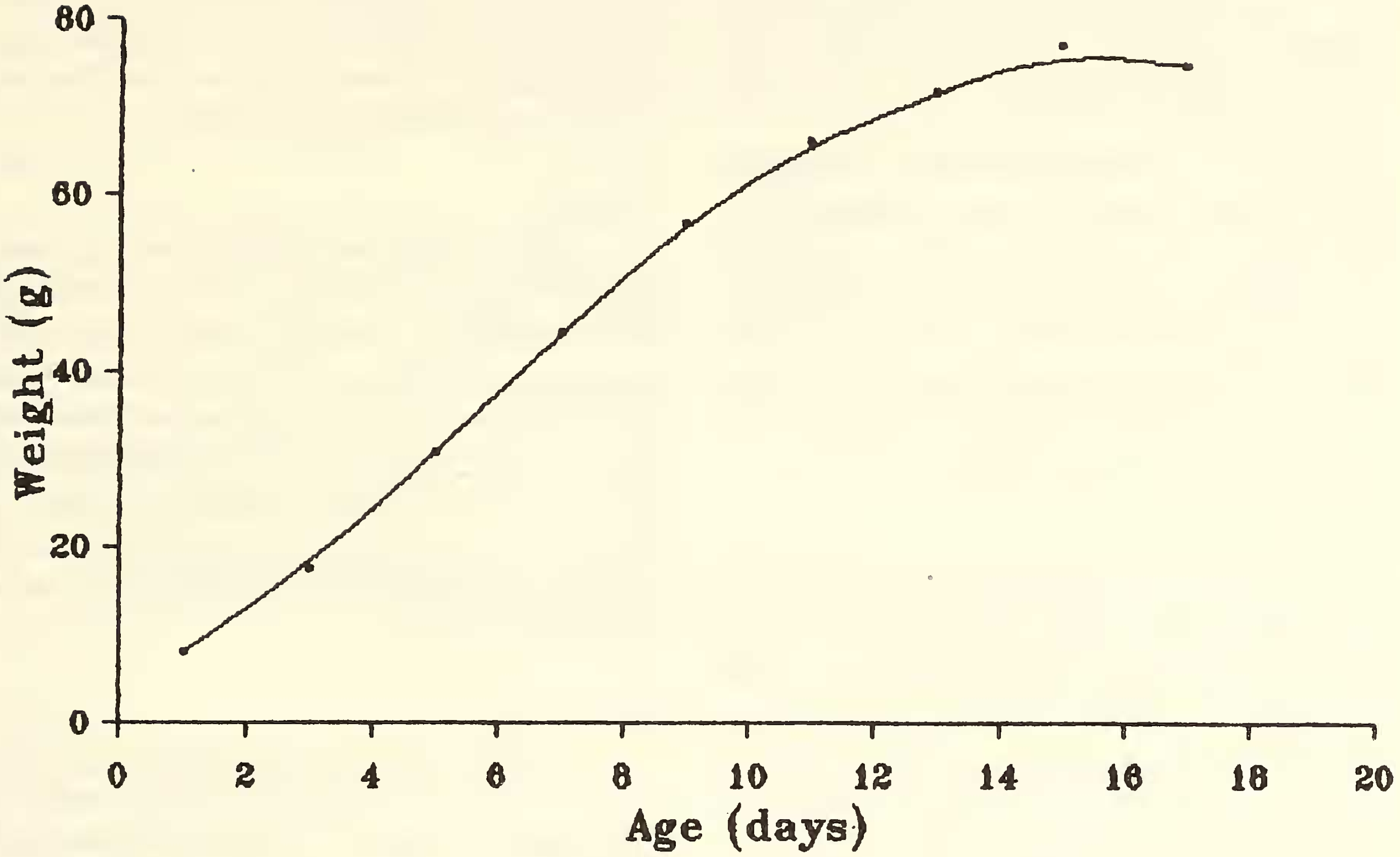

Fig. 3. Weight increase with age in nestlings of Common Myna *Acridotheres tristis* during 1992

Nestling period

The nestling period, i.e., time lapsed between hatching of the first young and fledging of all young in a nest, averaged 21.75 ± 2.38 (sd) days (n = 16) and ranged from 17 to 25 days. Pox-infected unhealthy young spend longer periods in the nests and such cases were not included in calculations.

Nesting success and Nestling mortality

In all, 78 young fledged from 227 eggs laid in 54 nests, a nesting success of 34.4% (Table 11). This means that each nesting pair, on an average, fledged 1.4 young. Seventy-two nestlings were lost to the following mortality factors.

TABLE 11
NESTING SUCCESS AND NESTLING MORTALITY IN COMMON MYNA (N = 54 NESTS)

	Number	% of total eggs	% of young hatched
Total eggs laid	227		
Young hatched	150		
Young fledged	78	34.4	52.0
Young died	72	31.7	48.0
Predation	21	9.3	14.0
Intraspecific rivalry	17	0.5	11.3
Starvation	11	4.9	7.3
Pox virus	8	3.5	5.3
Dust storm	3	1.3	2.0
Unknown reasons	12	5.3	8.0

Pox virus:

Pox virus infected 13 young in 6 broods, of which 5 fledged and 8 died, a nestling mortality of 5.3% (Table 11). The virus was diagnosed by the presence of small tubercles on the naked areas around the eyes and beak. In addition, skin rashes were found on the rest of the body. The plumage of infected young appeared rough and dry with small white patches falling off the skin. With the progress of the virus infection, the eyes were almost completely closed and the young were probably half blind. The infected young did not die quickly but instead stayed on in the nest for 4-10 days more than the average nestling period. The fledging of infected young apparently depended upon the degree of infection, those with comparatively lesser infection could fledge. The virus was diagnosed by the Virology Department of Punjab Agricultural University as "*Acridotheres tristis* pox-virus".

Starvation:

As a result of asynchronous hatching, the developing young were of different sizes and weights. In some cases, the difference in weight of nestlings of the brood soon narrowed down and the young attained almost equal weight and size in a few days. But in others, especially in larger broods, one or two young continued to remain smaller and weaker than their brood mates with very little increase in weight. Such nestlings died in the nest and their death was considered to be due to starvation. Eleven young (4.9% of total eggs laid, 7.3% of eggs hatched) died because of this reason (Table 11).

Intraspecific rivalry:

In four different instances, all young of the brood were found to have been wounded and thrown out of the nests. In all, 17 (11.3%) nestlings died in this way (Table 11). Circumstantial evidence suggested that this was the outcome of intraspecific rivalry.

Predation:

When normal and healthy nestlings were found missing from the nest, it was considered a case of predation. In all the natural open nests, this type of predation led to the destruction of the whole brood. But in nest boxes and hole nests, only one young was found missing at a time. In one box with a single young aged 10 days, a blood smear on the rim of the nest hole indicated predation. In total, 21 (14%) young were lost to predation (Table 11).

Dust storms:

Only one open nest was destroyed in a dust storm killing three young (2% nesting mortality). The inmates of nest boxes and hole nests were not affected by this factor.

Effect of laying season, brood number and habitat on hatching and nesting success

Laying season and brood number did not affect hatching and nesting success (Tables 12 and 13). Also, habitat did not affect these two parameters whether all broods were pooled or only the first broods were analysed separately (Table 14).

TABLE 12

EFFECT OF LAYING SEASON ON HATCHING AND NESTING SUCCESS IN COMMON MYNA

	Hatching success (%)			Nesting success (%)		
	n	Mean ± se	Average rank	n	Mean ± se	Average rank
Early (April)	19	71.14 ± 7.22	25.55	19	31.23 ± 7.29	23.74
Mid (May)	12	77.92 ± 0.08	28.58	11	27.27 ± 7.15	22.09
Late (June-July)	19	71.93 ± 6.22	23.50	19	40.79 ± 7.18	27.95
Difference among seasons (Kruskal-Wallis ANOVA by ranks)	*K-W* statistic = 0.94 $P = 0.62$			*K-W* statistic = 1.48 $P = 0.48$		

TABLE 13
EFFECT OF BROOD NUMBER ON HATCHING AND NESTING SUCCESS IN COMMON MYNA

Brood	Hatching success (%)			Nesting success (%)		
	n	Mean ± se	Average rank	n	Mean ± se	Average rank
First	38	68.42 ± 5.72	27.68	37	27.43 ± 4.95	24.03
Second	12	69.72 ± 8.26	25.96	12	41.95 ± 7.24	32.04
Third	3	72.22 ± 2.78	22.50	13	50.00 ± 25.0	34.83
Difference (Kruskal-Wallis ANOVA by ranks)	*K-W* statistic = 0.40 $P = 0.82$			*K-W* statistic = 3.73 $P = 0.16$		

Table 14
EFFECT OF HABITAT ON HATCHING AND NESTING SUCCESS IN COMMON MYNA

Habitat	Hatching success (%)			Nesting success (%)		
	n	Mean ± se	Average rank	n	Mean ± se	Average rank
All broods pooled						
Fish farm	15	58.99 ± 7.9	15.10	15	31.66 ± 8.5	17.07
Poultry farm	3	58.33 ± 30.1	17.00	3	16.67 ± 16.7	11.83
Shisham woodlot	6	80.00 ± 11.9	23.42	6	33.33 ± 10.9	17.42
Forestry area	9	80.00 ± 6.0	21.94	9	49.63 ± 8.7	22.94
Orchards	3	66.67 ± 17.6	16.83	3	46.66 ± 6.7	21.17
Difference (Kruskal-Wallis ANOVA by ranks)	*K-W* statistic = 4.09 $P = 0.394$			*K-W* statistic = 3.47 $P = 0.483$		
First broods alone						
Fish farm	7	58.09 ± 13.9	9.64	7	30.47 ± 13.9	10.50
Poultry farm	3	58.33 ± 30.1	9.83	3	16.67 ± 16.7	8.33
Shisham woodlot	4	76.25 ± 17.7	13.13	4	25.00 ± 15.0	9.88
Forestry area	4	80.00 ± 8.2	12.50	4	38.75 ± 15.3	12.38
Orchards	3	66.67 ± 17.6	10.50	3	46.67 ± 6.7	14.50
Difference (Kruskal-Wallis ANOVA by ranks)	*K-W* statistic = 1.198 $P = 0.878$			*K-W* statistic = 2.021 $P = 0.732$		

Comparison of nesting success in open and hole nests in natural sites

Of 14 open nests in natural sites, 9 (64.3%) failed before fledging but 5 (35.7%) were successful, i.e. produced atleast one fledgling. On the contrary, 8 of 10 (80%) hole nests were successful and only 2 (20%) failed. Nesting success, therefore, was significantly greater in hole nests than in open nests (Fisher's exact test, $P = 0.047$)

DISCUSSION

Common mynas in our study initiated breeding activity in March and continued until September, as also mentioned in Dewar (1929), Baker (1933) and Ali and Ripley (1987). The long breeding season of this species allows breeding pairs to raise two or even three successive broods. Although insect food for the nestlings in April-May (when early breeders rear their young) is not as abundant as in the monsoon (July-September), breeding early in the season may be adaptive in acquiring better nesting sites.

Commonly used nesting material included twigs, leaves, feathers, paper, plastics etc., although snake moultings and metallic foil were also used occasionally. Lamba (1963) and Panicker (1980) have also recorded similar materials in common myna nests. In our study, twigs and leaves of neem and dhrek were most frequently used as nesting material. Earlier, Sengupta (1981) found house sparrows *Passer domesticus* using leaves of neem as nesting material in preference to other available vegetation, probably to repel nest arthropods. The use of nest material as insecticidal and anti-pathogenic agents has also been reported for other species of birds (Wimberger, 1984; Clark and Mason, 1985). The relative proportion of other types of material probably depended upon their availability in the vicinity of the nest. For example, in nests in the poultry farm area, a large number of poultry feathers was used, whereas fish scales were found in nests around fish ponds. Use of huge quantity of nesting material in cavity nests and boxes may be important because the common myna does not incubate eggs consistently (Panicker, 1980) and nesting material may help in keeping the nests well insulated. Cavity nesters like parakeets do not use much nesting material but incubate eggs much more consistently as compared to the common myna. Since the common myna breeds in open nests, cavity nesting seems to be a secondary adaptation.

So far, little information was available on the egg weight of the common myna. Panicker (1980) reported egg weight from Delhi and Tamil Nadu. Weight of fresh eggs in our study ranged from 6.0 to 8.5 g and averaged 7.36 ± 0.59 g which is quite close to Panicker (1980; 7.0 g). His results are not comparable to ours because he did not provide variance and sample size. Average egg weight was significantly different among individual clutches, which was probably due to difference in the age or body condition of the laying female.

Average egg size in our study (29.11 x 21.41 mm) was comparable to that reported by Baker (1933) and Lamba (1963) but appeared greater than in Panicker's (1980) study (27.3 x 19.7 mm). Since these authors did not mention the sample sizes and/or variance, statistical comparison of egg size was not possible.Like egg weight, significant differences among clutches in all parameters of egg size suggested that this was different among different females. Both volume and breadth of eggs differed significantly among different habitats, suggesting that these parameters were probably affected by the availability of food. Eggs from nests in poultry farms had the largest volume and breadth, whereas those from shisham woodlot had the smallest values for these parameters. Egg volume was not affected by laying sequence. In other species, however, egg volume may increase as in the least flycatcher *Empidonax minimus* (Briskie and Sealy, 1990) or decrease with laying sequence as in the American crow *Corvus brachyrhynchos* (Ignatiuk and Clark, 1991). Brood number and laying month also did not affect length, breadth and volume of eggs, probably because the food supply available to breeding birds remained the same throughout the breeding season in our area.

Average clutch size (4.29 ± 0.85, n = 52) in our study did not differ significantly from that reported by Lamba (1963) from Tamil Nadu (4.4 ± 0.50, n = 20, t = 0.54, df = 70, ns) and by Panicker (1980) from Delhi (4.6 ± 1.17, n = 3, t = 0.60, df = 53, ns). However, it was significantly greater than that observed by Panicker (1980) in Tamil Nadu (3.45 ± 0.54, n = 11, t 3.13, df = 61, P < 0.005). Clutch size tends to increase with increasing latitude in both passerine and non-passerine birds (Lack, 1968). Clutch size in our study area, therefore, should have been greater than that in southern study areas of Lamba (1963) and Panicker (1980). This holds true for comparison with Panicker's (1980) data. Why Lamba (1963) recorded higher clutch size is not clear.

Clutch size of pairs nesting early in the breeding season was greater than those nesting late, which was probably because of the age of egg laying females. Birds breeding for the first time generally start egg laying later than older birds and hence have smaller clutches (Perrins, 1965). In nests where more than one brood was reared, we assumed that these were occupied by the same pairs as evident from their behaviour. Successive clutches in such nests were smaller than the earlier ones. Probably, body condition of the egg laying females is comparatively better when they lay the first than when they lay the second and third broods. Seasonal decline in clutch size has also been reported within age groups in song sparrow *Melospiza melodia* (Hochachka 1990). However, tree creepers *Certhia familiaris* lay largest clutches in the middle of the breeding season (Kuitunen and Aleknonis, 1992).

Average incubation period (12.73 d) in our study was significantly shorter as compared to 17-18 d reported by Lamba (1963). This was because he defined incubation period as the time lag between laying and hatching of the first egg, whereas we measured it as the time elapsed between the laying and hatching of the last egg. Further, the incubation period of birds breeding at higher latitudes is shorter than those breeding at lower latitudes (Lack, 1968). Lamba's study area (Madras), was located at much lower latitude than our study area which may also have contributed to this difference in incubation period. However, incubation period measured in our study is comparable to other studies (Sengupta, 1968; Panicker, 1980).

Hatching success was fairly high (66%) and comparable to Panicker's (1980) study. The major factor of egg loss was hatching failure (18.5%) followed by predation (9.7%). Sterility or infection of the embryo could result in hatching failure. About 70% of eggs in passerines that do not hatch are infected with pathogens such as *Escherichia coli* and *Staphylococcus epidermitis* (Pinowski *et al.* 1991).

The growth in weight of altricial young followed logistic growth curve which is typical for passerines (Ricklefs, 1968). Nestlings attained maximum weight exactly two weeks after hatching, after which they started losing weight. The lesser the number of young in a brood, the more was the average weight, probably because they were better fed than those in larger broods.

One or two nestlings in larger broods were usually underfed and these died in the nests. In birds with asynchoronous hatching, brood size is adjusted according to the availability of food (Ricklefs, 1965). Parents feed the most active members of the brood at priority. But when food is limited, only the largest or the first hatched survive. This behaviour, known as brood reduction, may minimize the amount of effort wasted in feeding extra young and enhance the survival and long-term fitness of parents (Ignatiuk and Clark, 1991). Brood reduction has also been reported in three species of weaverbirds in Punjab (Dhindsa, 1980).

Nestlings period (time lag between hatching of first young and fledging of all young) was 21.75 days. This is comparable to that mentioned in Ali and Ripley (1987), although Lamba (1963) reported it to be 2-3 weeks. Nestling period probably depended upon the number of young in a brood, productivity of the habitat, nest height and age of parents. Nesting success was higher (34%) in our study as compared to Panicker (1980; 28.6%) although his study was confined to those mynas which used tree holes as breeding sites. Laying season, brood number and habitat did not affect hatching and nesting success of the common myna.

Our study is the first to examine the effect of habitat, brood number and laying season on the reproductive output of common mynas. Success of hole nests and open nests of this species has also been compared for the first time. Higher nesting success in hole nests (80%) compared with open nests (35.7%) may be attributed to the following reasons:

1. Hole nests are safer as compared to open nests, because nest contents are out of the reach of avian predators. In our study, none of the open nests of the common myna was successful when there was the nest of house crow *Corvus splendens* on the same tree. The presence of crow nests did not lead to failure of cavity nests of the common myna.

2. Natural calamities like dust storms and heavy rains, which occur frequently during breeding season, do not harm cavity nests. On the contrary, these factors often result in the failure of open nests.

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